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Nishisaka et al.

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(54) **TRANSMISSION DEVICE AND METHOD OF CONTROLLING TRANSMISSION DEVICE**

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H04B 10/07 (2013.01)
G02B 6/42 (2006.01)
H04L 1/00 (2006.01)

(52) **U.S. Cl.**
CPC ***H04B 10/07*** (2013.01); ***G02B 6/4284*** (2013.01); ***G02B 6/4292*** (2013.01); ***H04L 1/0057*** (2013.01)

(58) **Field of Classification Search**
CPC . H04L 1/0057; H04L 43/16; H04J 2203/006; G02B 6/4292; G02B 6/4284; H04B 10/40
USPC 340/517; 398/128, 135, 138
See application file for complete search history.

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(57) **ABSTRACT**

A transmission device includes: a plurality of detectors configured to respectively detect alarms of a plurality of frame signals having divided client signals respectively; a memory configured to store group information indicating a group in which the client signal is in common regarding the plurality of frame signals; a specifying portion configured to specify, based on the group information, a second frame signal storing the client signal in common with a first frame signal in which a first alarm is detected by one of the plurality of detectors among the plurality of frame signals; and one or more generators configured to generate a second alarm for the second frame signal.

12 Claims, 14 Drawing Sheets

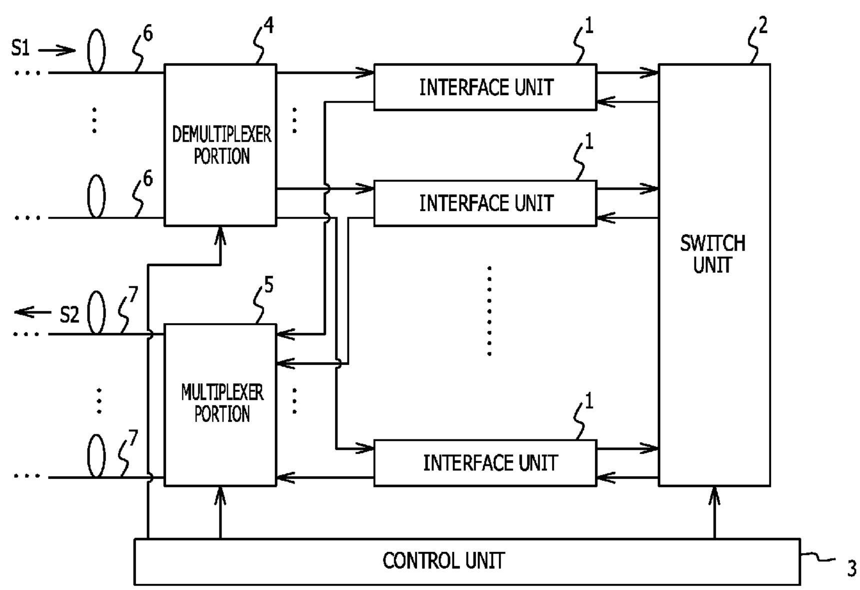
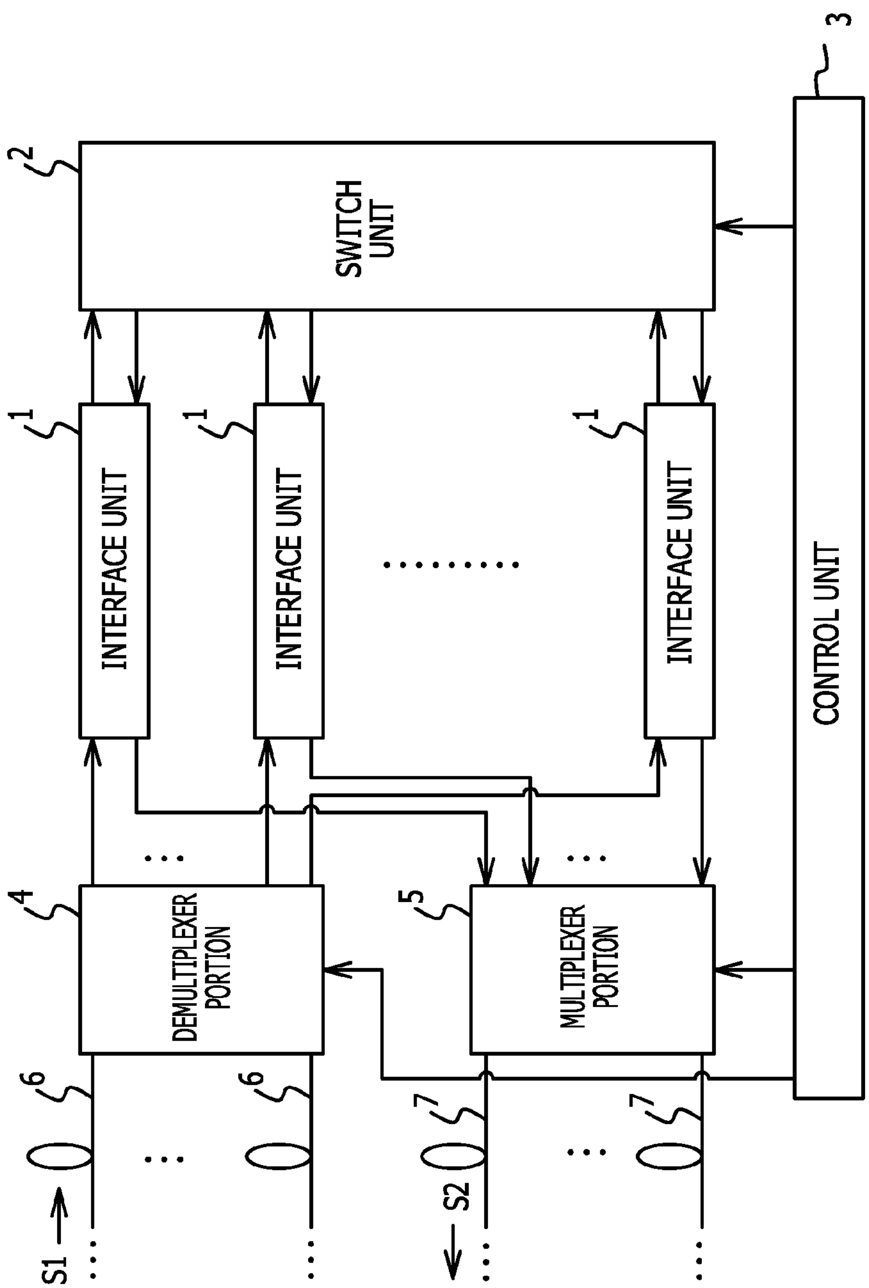


FIG. 1



SWITCH UNIT
INTERFACE UNIT
INTERFACE UNIT
INTERFACE UNIT
CONTROL UNIT
DEMULTIPLEXER PORTION
MULTIPLEXER PORTION
S1
S2
1
2
3
4
5
6
7

FIG. 2

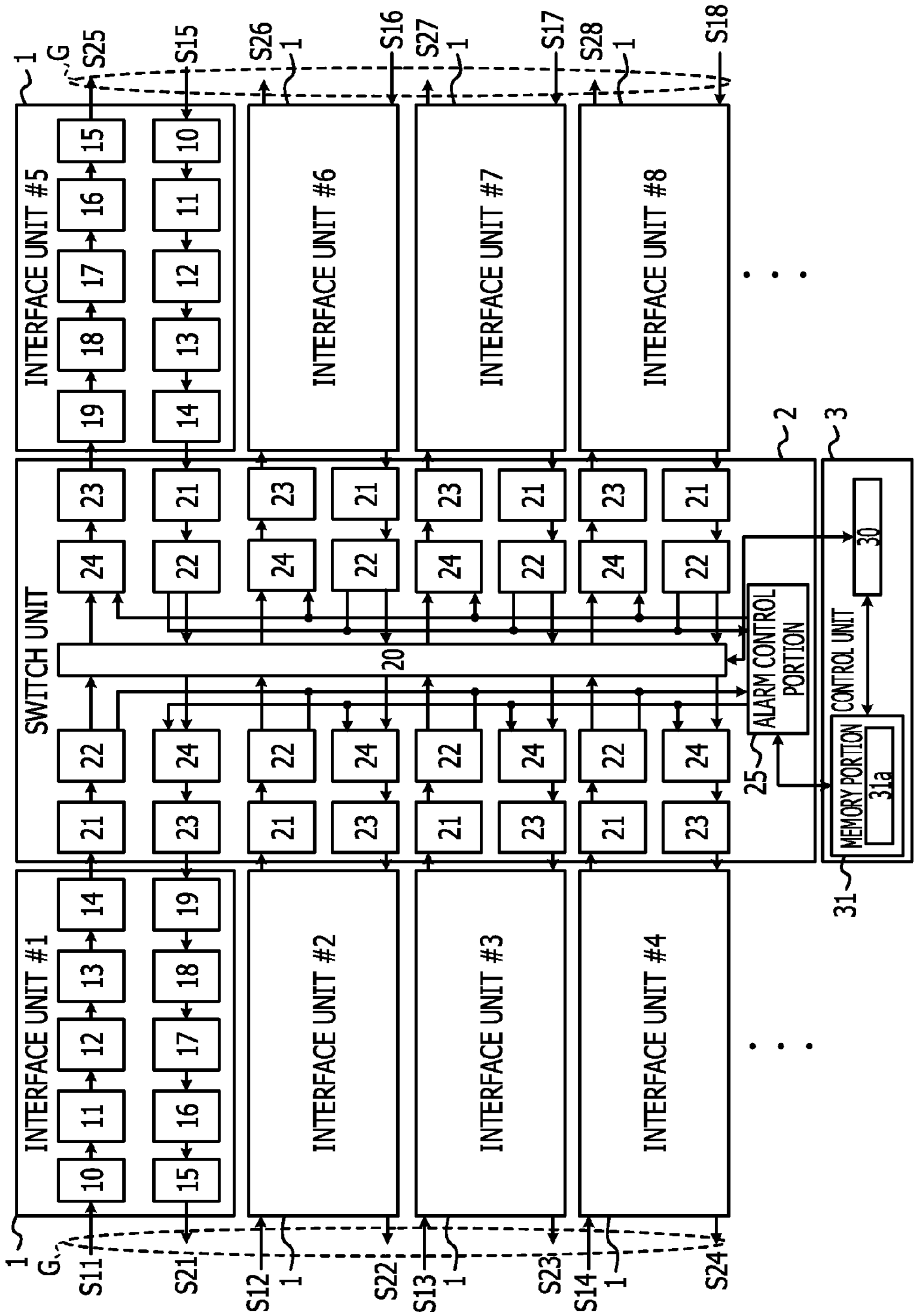

INTERFACE UNIT #1
INTERFACE UNIT #2
INTERFACE UNIT #3
INTERFACE UNIT #4
INTERFACE UNIT #5
INTERFACE UNIT #6
INTERFACE UNIT #7
INTERFACE UNIT #8
SWITCH UNIT
ALARM CONTROL PORTION
CONTROL UNIT
MEMORY PORTION
31a
30
20
25
31
2
3
1
G
S11
S12
S13
S14
S15
S16
S17
S18
S21
S22
S23
S24
S25
S26
S27
S28
10
11
12
13
14
15
16
17
18
19
21
22
23
24

FIG. 3

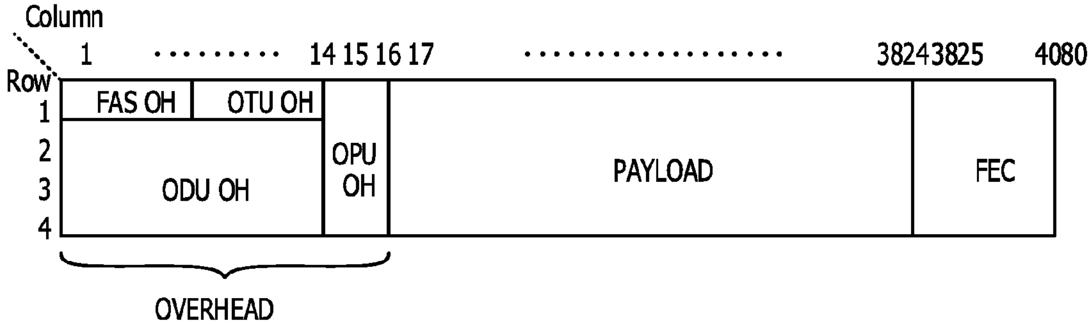

Column
Row
1
. . . .
14 15 16 17
. . . .
38243825
4080
1
2
3
4
FAS OH
OTU OH
ODU OH
OPU OH
PAYLOAD
FEC
OVERHEAD

FIG. 4

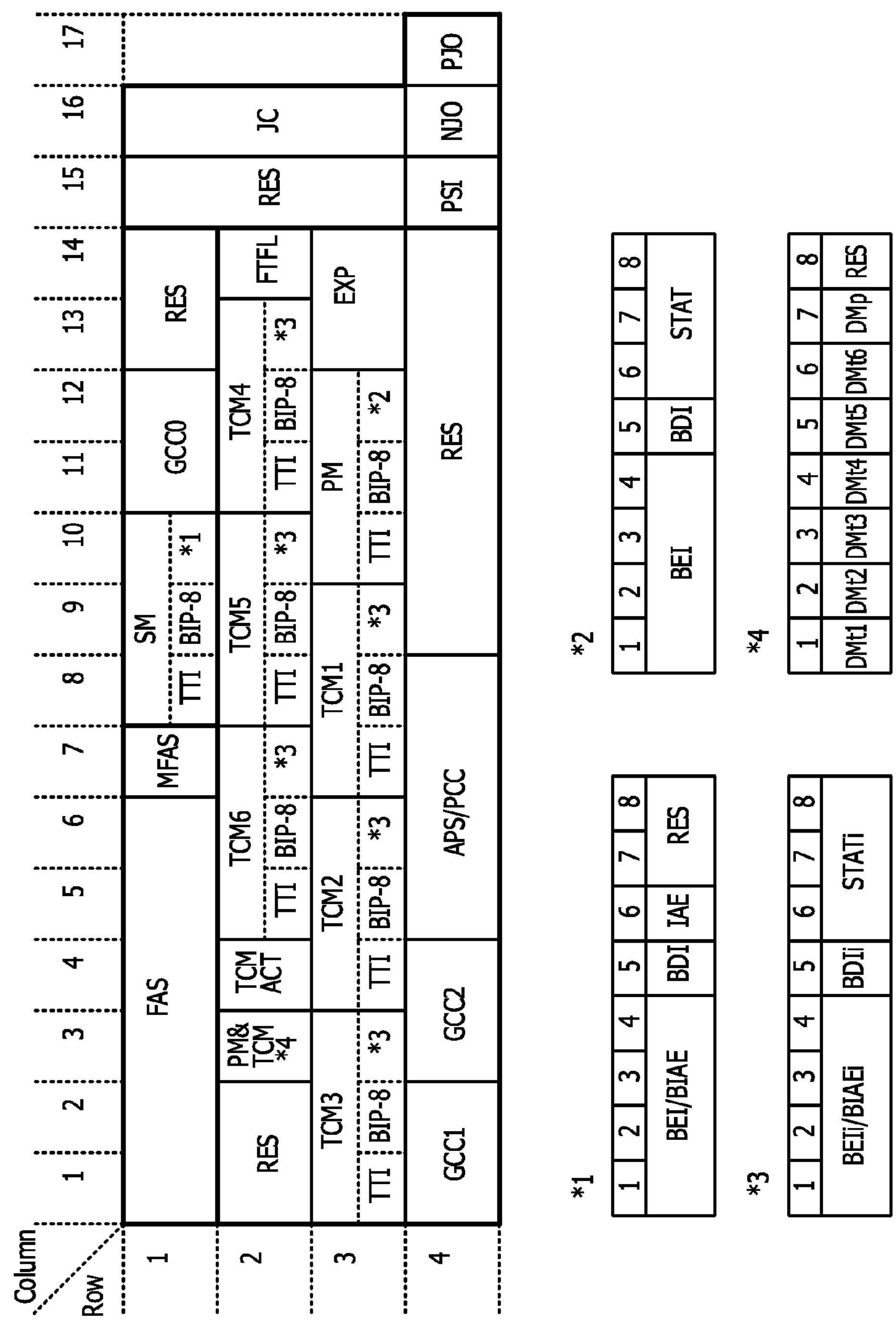

Column
Row
FAS
MFAS
SM
TTI
BIP-8
*1
GCC0
RES
JC
RES
PM&TCM *4
TCM ACT
TCM6
TCM5
TCM4
FTFL
TCM3
TCM2
TCM1
PM
EXP
*2
*3
GCC1
GCC2
APS/PCC
PSI
NJO
PJO
BEI/BIAE
BDI
IAE
BEI
STAT
BEIi/BIAEi
BDIi
STATi
DMt1
DMt2
DMt3
DMt4
DMt5
DMt6
DMp

FIG. 5

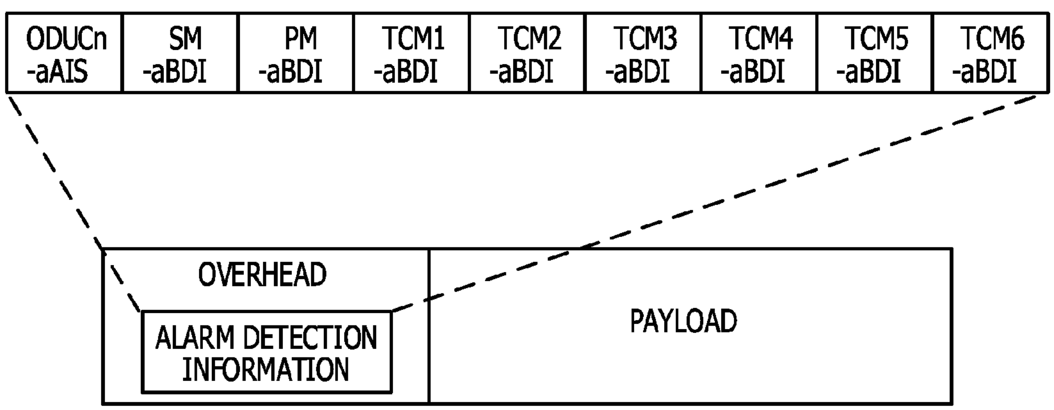

ODUCn -aAIS
SM -aBDI
PM -aBDI
TCM1 -aBDI
TCM2 -aBDI
TCM3 -aBDI
TCM4 -aBDI
TCM5 -aBDI
TCM6 -aBDI
OVERHEAD
ALARM DETECTION INFORMATION
PAYLOAD

FIG. 6A

	FORWARD INTERFACE UNIT							
	#1	#2	#3	#4	#5	#6	#7	#8
#1	0	0	0	0	1	1	1	1
#2	0	0	0	0	1	1	1	1
#3	0	0	0	0	1	1	1	1
#4	0	0	0	0	1	1	1	1
#5	1	1	1	1	0	0	0	0
#6	1	1	1	1	0	0	0	0
#7	1	1	1	1	0	0	0	0
#8	1	1	1	1	0	0	0	0

P1

FIG. 6B

	BACKWARD INTERFACE UNIT							
	#1	#2	#3	#4	#5	#6	#7	#8
#1	1	1	1	1	0	0	0	0
#2	1	1	1	1	0	0	0	0
#3	1	1	1	1	0	0	0	0
#4	1	1	1	1	0	0	0	0
#5	0	0	0	0	1	1	1	1
#6	0	0	0	0	1	1	1	1
#7	0	0	0	0	1	1	1	1
#8	0	0	0	0	1	1	1	1

P2

FIG. 7

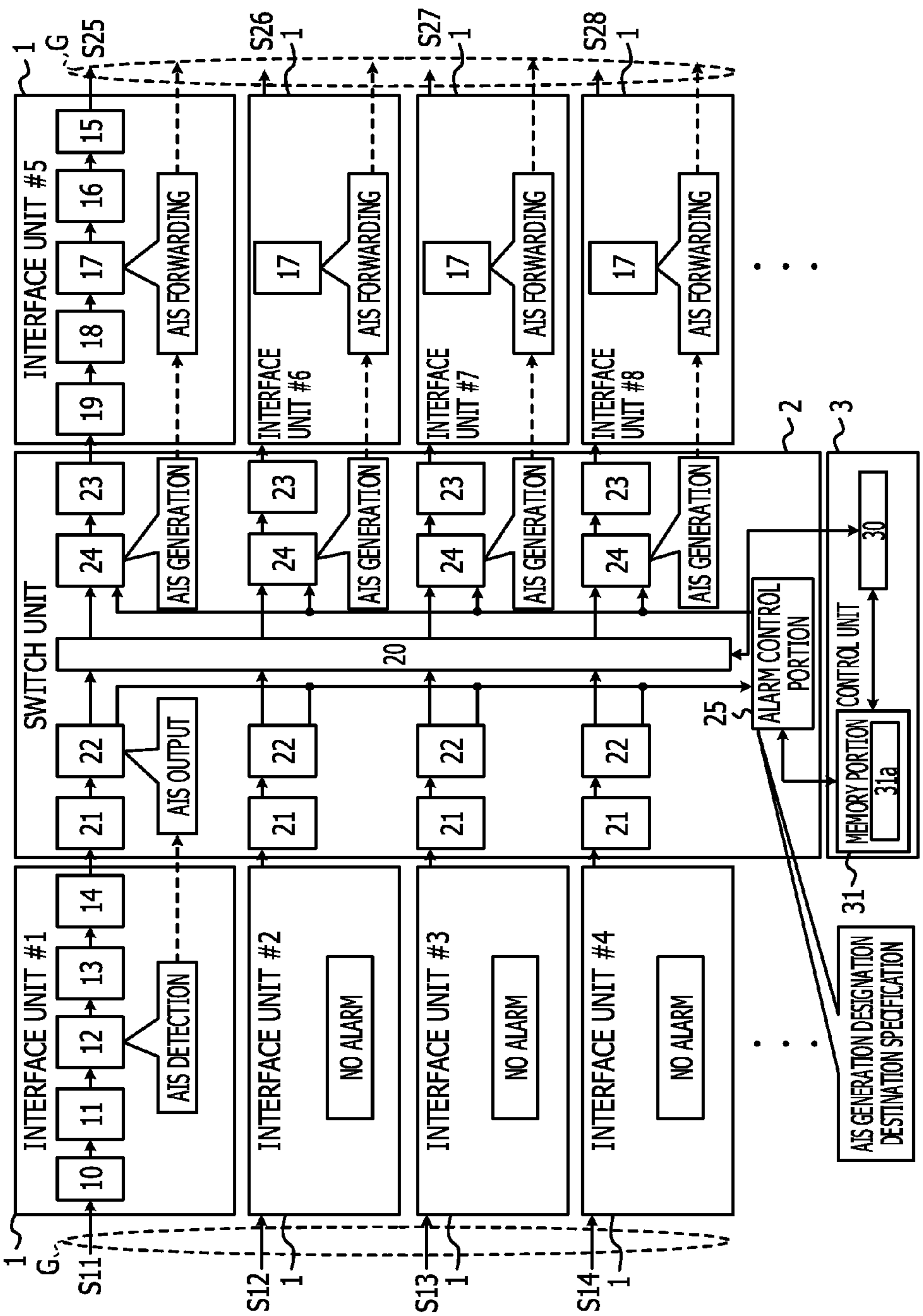
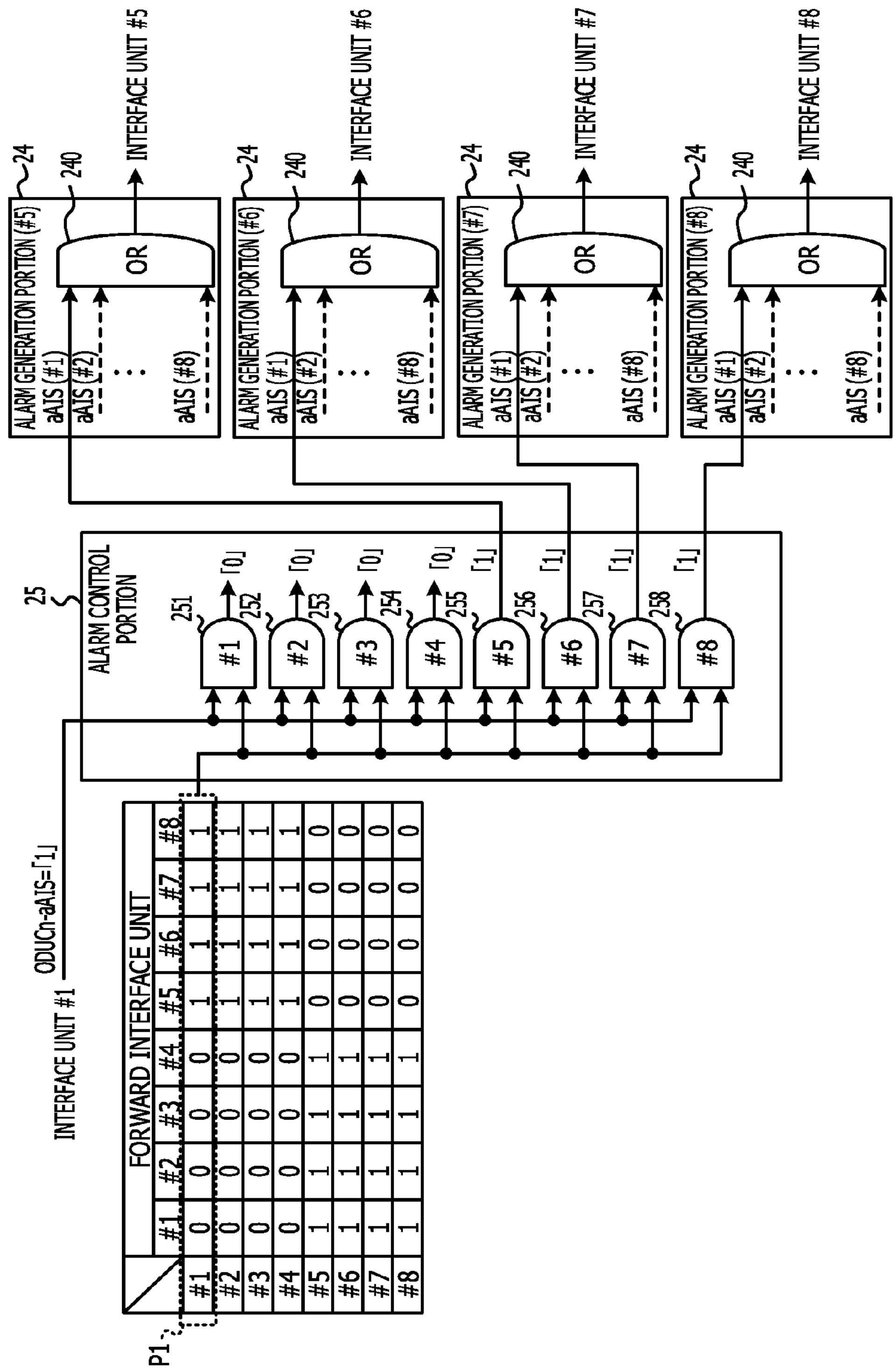

INTERFACE UNIT #1
10
11
12
13
14
AIS DETECTION
INTERFACE UNIT #2
NO ALARM
INTERFACE UNIT #3
NO ALARM
INTERFACE UNIT #4
NO ALARM
SWITCH UNIT
21
22
AIS OUTPUT
20
24
23
AIS GENERATION
ALARM CONTROL PORTION
25
INTERFACE UNIT #5
19
18
17
16
15
AIS FORWARDING
INTERFACE UNIT #6
INTERFACE UNIT #7
INTERFACE UNIT #8
CONTROL UNIT
30
MEMORY PORTION
31a
31
2
3
1
G
S11
S12
S13
S14
S25
S26
S27
S28
AIS GENERATION DESIGNATION DESTINATION SPECIFICATION

FIG. 8



	#1	#2	#3	#4	#5	#6	#7	#8
#1	0	0	0	0	1	1	1	1
#2	0	0	0	0	1	1	1	1
#3	0	0	0	0	1	1	1	1
#4	0	0	0	0	1	1	1	1
#5	1	1	1	1	0	0	0	0
#6	1	1	1	1	0	0	0	0
#7	1	1	1	1	0	0	0	0
#8	1	1	1	1	0	0	0	0

FIG. 9

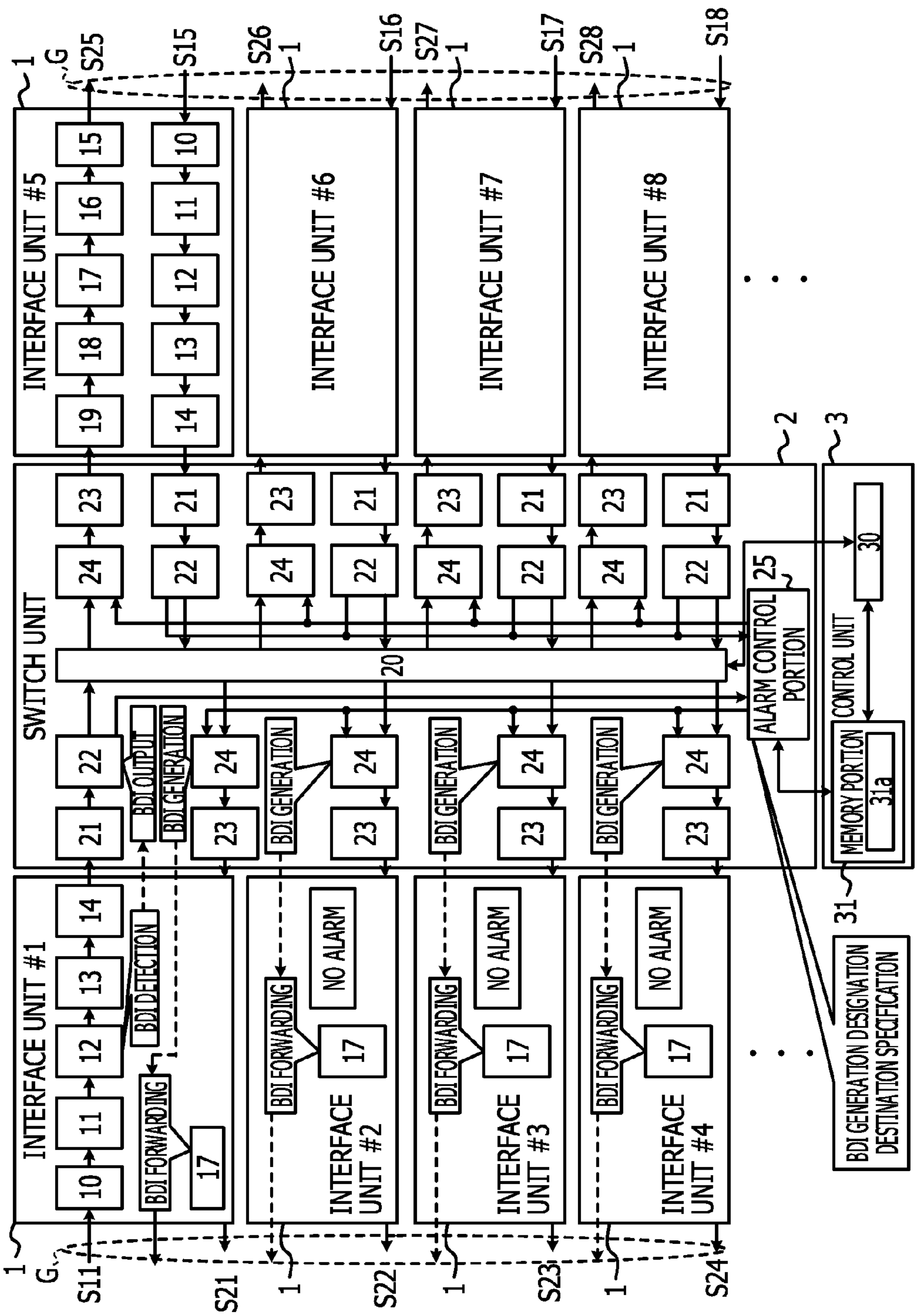
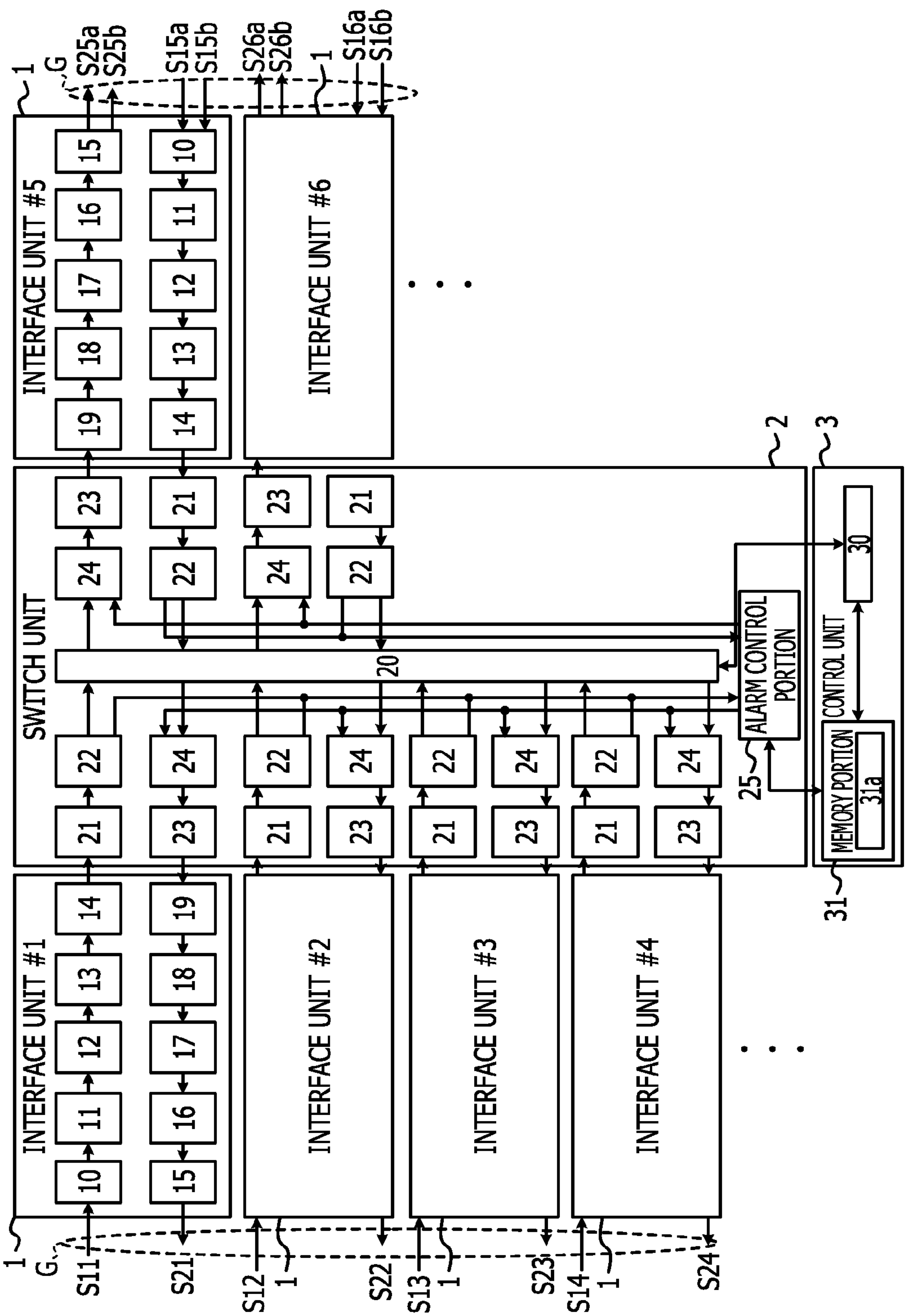

INTERFACE UNIT #5
INTERFACE UNIT #6
INTERFACE UNIT #7
INTERFACE UNIT #8
SWITCH UNIT
ALARM CONTROL PORTION
CONTROL UNIT
MEMORY PORTION
31a
30
20
25
BDI OUTPUT
BDI GENERATION
BDI DETECTION
BDI FORWARDING
NO ALARM
INTERFACE UNIT #1
INTERFACE UNIT #2
INTERFACE UNIT #3
INTERFACE UNIT #4
BDI GENERATION DESIGNATION DESTINATION SPECIFICATION
S11
S21
S22
S23
S24
S15
S16
S17
S18
S25
S26
S27
S28
G

FIG. 10



INTERFACE UNIT #1
INTERFACE UNIT #2
INTERFACE UNIT #3
INTERFACE UNIT #4
INTERFACE UNIT #5
INTERFACE UNIT #6
SWITCH UNIT
ALARM CONTROL PORTION
CONTROL UNIT
MEMORY PORTION
31a
30
20
25
31
1
2
3
G
10
11
12
13
14
15
16
17
18
19
21
22
23
24
S11
S21
S12
S22
S13
S23
S14
S24
S25a
S25b
S15a
S15b
S26a
S26b
S16a
S16b

FIG. 11A

	FORWARD INTERFACE UNIT					
	#1	#2	#3	#4	#5	#6
#1	0	0	0	0	1	1
#2	0	0	0	0	1	1
#3	0	0	0	0	1	1
#4	0	0	0	0	1	1
#5	1	1	1	1	0	0
#6	1	1	1	1	0	0

P3

FIG. 11B

	BACKWARD INTERFACE UNIT					
	#1	#2	#3	#4	#5	#6
#1	1	1	1	1	0	0
#2	1	1	1	1	0	0
#3	1	1	1	1	0	0
#4	1	1	1	1	0	0
#5	0	0	0	0	1	1
#6	0	0	0	0	1	1

P4

FIG. 12

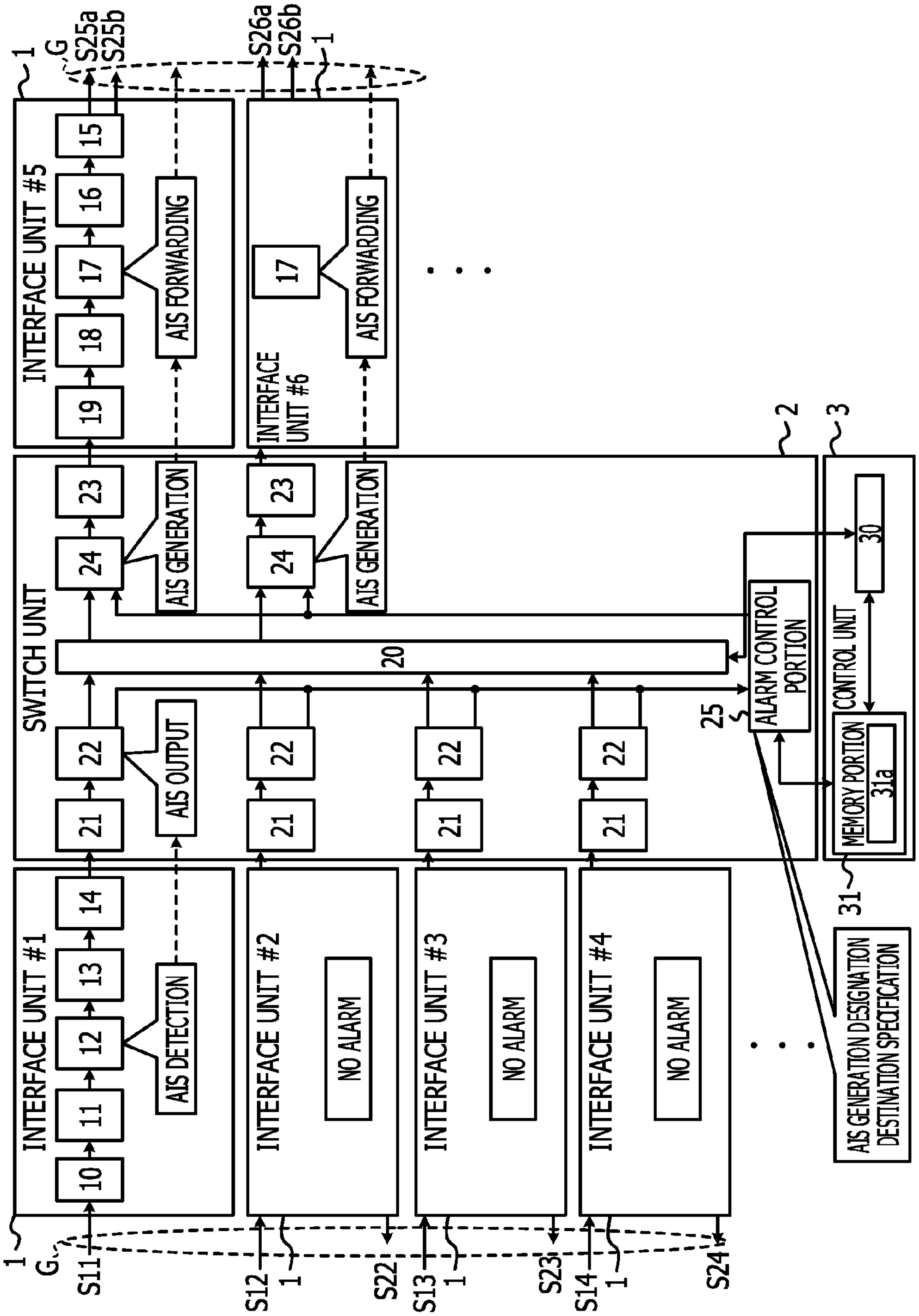

INTERFACE UNIT #1
10
11
12
13
14
AIS DETECTION
INTERFACE UNIT #2
NO ALARM
INTERFACE UNIT #3
NO ALARM
INTERFACE UNIT #4
NO ALARM
S11
S12
S13
S14
S22
S23
S24
G
1
SWITCH UNIT
21
22
AIS OUTPUT
20
24
23
AIS GENERATION
25
ALARM CONTROL PORTION
2
3
CONTROL UNIT
30
MEMORY PORTION
31a
31
AIS GENERATION DESIGNATION DESTINATION SPECIFICATION
INTERFACE UNIT #5
19
18
17
16
15
AIS FORWARDING
INTERFACE UNIT #6
S25a
S25b
S26a
S26b

FIG. 13

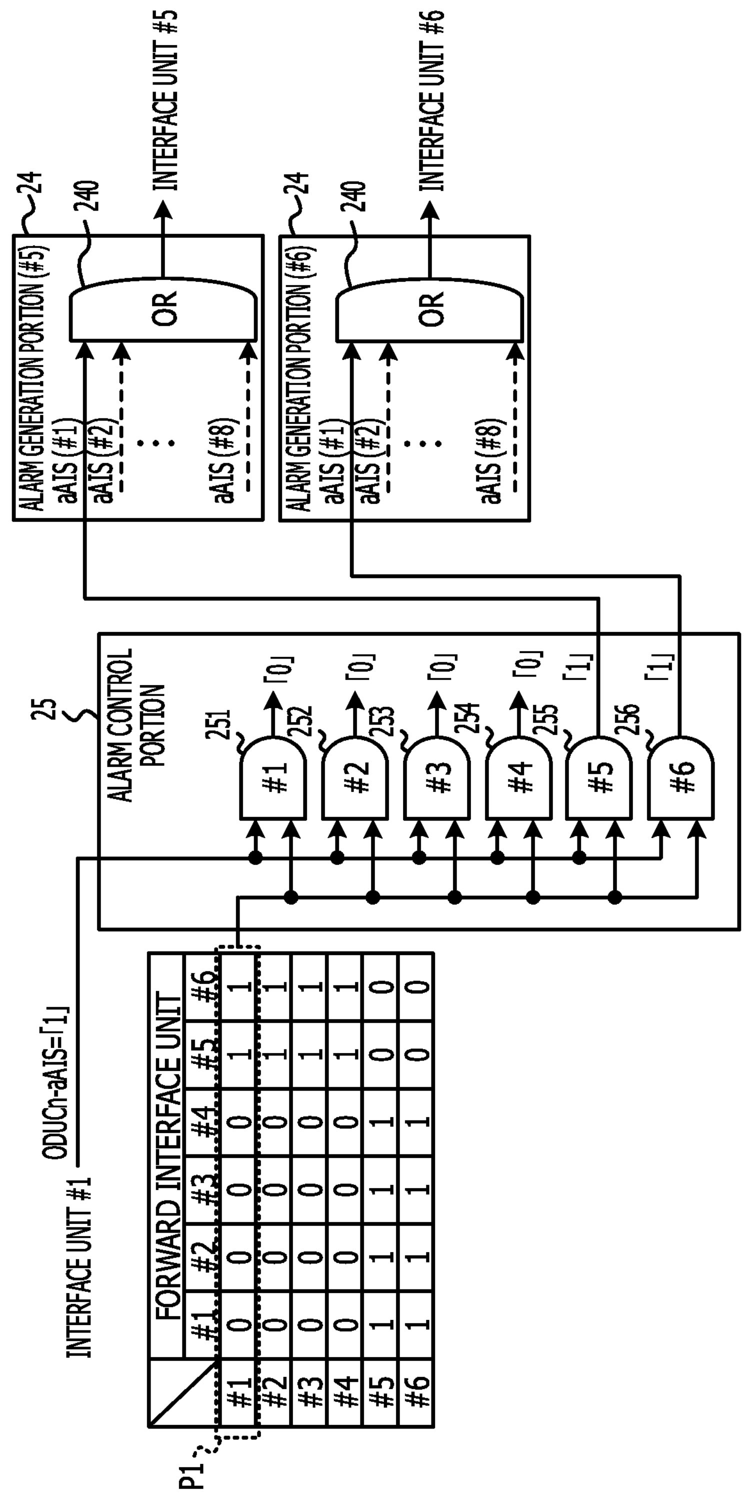
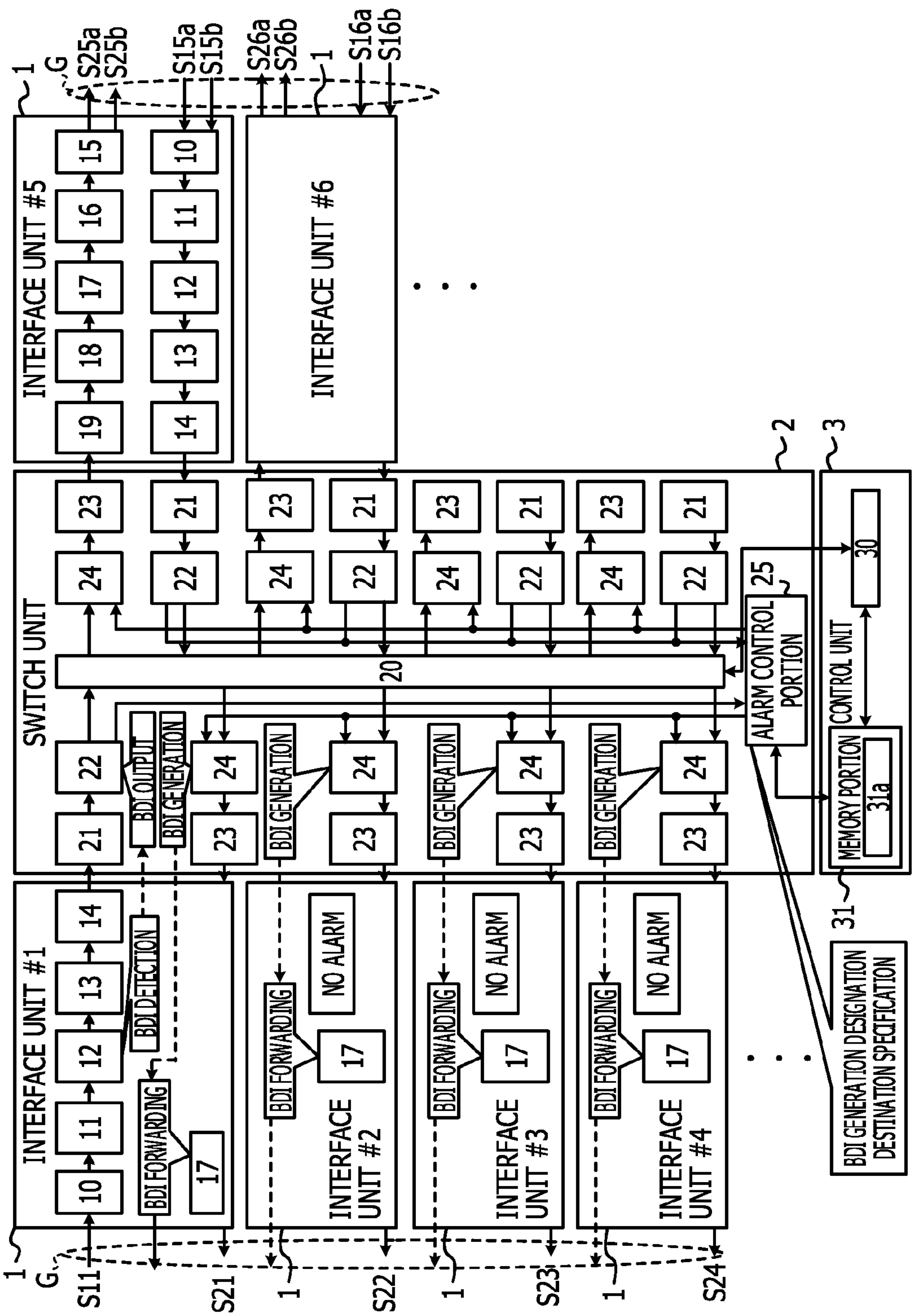

INTERFACE UNIT #5
INTERFACE UNIT #6
24
240
ALARM GENERATION PORTION (#5)
ALARM GENERATION PORTION (#6)
OR
aAIS (#1)
aAIS (#2)
aAIS (#8)
25
ALARM CONTROL PORTION
251
252
253
254
255
256
#1
#2
#3
#4
#5
#6
「0」
「1」
INTERFACE UNIT #1
ODUCn-aAIS=「1」
FORWARD INTERFACE UNIT
P1
#1 0 0 0 0 1 1
#2 0 0 0 0 1 1
#3 0 0 0 0 1 1
#4 0 0 0 0 1 1
#5 1 1 1 1 0 0
#6 1 1 1 1 0 0

FIG. 14


SWITCH UNIT
INTERFACE UNIT #1
INTERFACE UNIT #2
INTERFACE UNIT #3
INTERFACE UNIT #4
INTERFACE UNIT #5
INTERFACE UNIT #6
BDI DETECTION
BDI FORWARDING
BDI OUTPUT
BDI GENERATION
NO ALARM
ALARM CONTROL PORTION
CONTROL UNIT
MEMORY PORTION
31a
30
20
25
BDI GENERATION DESIGNATION DESTINATION SPECIFICATION
S11
S21
S22
S23
S24
S15a
S15b
S25a
S25b
S16a
S16b
S26a
S26b
G

TRANSMISSION DEVICE AND METHOD OF CONTROLLING TRANSMISSION DEVICE

CROSS-REFERENCE TO RELATED APPLICATION

This application is based upon and claims the benefit of priority of the prior Japanese Patent Application No. 2014-009018, filed on Jan. 21, 2014, the entire contents of which are incorporated herein by reference.

FIELD

The embodiments discussed herein are related to a transmission device and a method of controlling a transmission device.

BACKGROUND

As communication demands increase, high speed optical transport systems are standardized. For example, the International Telecommunication Union Telecommunication Standardization Sector (ITU-T) Recommendation G.709 defines a technique of optical transport network (OTN) of approximately from 1.25 to 100 Gbps.

Related techniques are disclosed in Japanese Laid-open Patent Publication No. 11-308219 or Japanese Laid-open Patent Publication No. 2000-78153.

SUMMARY

According to an aspect of the embodiments, a transmission device includes: a plurality of detectors configured to respectively detect alarms of a plurality of frame signals having divided client signals respectively; a memory configured to store group information indicating a group in which the client signal is in common regarding the plurality of frame signals; a specifying portion configured to specify, based on the group information, a second frame signal storing the client signal in common with a first frame signal in which a first alarm is detected by one of the plurality of detectors among the plurality of frame signals; and one or more generators configured to generate a second alarm for the second frame signal.

The object and advantages of the invention will be realized and attained by means of the elements and combinations particularly pointed out in the claims.

It is to be understood that both the foregoing general description and the following detailed description are exemplary and explanatory and are not restrictive of the invention, as claimed.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** illustrates one example of functional configuration of a transmission device;

FIG. **2** illustrates one example of functional configuration of an interface unit and a switch unit;

FIG. **3** illustrates one example of an OTU frame;

FIG. **4** illustrates one example of an overhead of an OTU frame;

FIG. **5** illustrates one example of an intra-device frame;

FIG. **6**A illustrates one example of a forward table;

FIG. **6**B illustrates one example of a backward table;

FIG. **7** illustrates one example of a first behavior of a transmission device;

FIG. **8** illustrates one example of an alarm control portion and an alarm generation portion;

FIG. **9** illustrates one example of a second behavior of a transmission device;

FIG. **10** illustrates one example of functional configuration of an interface unit and a switch unit;

FIG. **11**A illustrates one example of a forward table;

FIG. **11**B illustrates one example of a backward table;

FIG. **12** illustrates one example of a third behavior of a transmission device;

FIG. **13** illustrates one example of an alarm control portion and an alarm generation portion; and

FIG. **14** illustrates one example of a fourth behavior of a transmission device.

DESCRIPTION OF EMBODIMENTS

Optical transmission in an OTN is carried out by storing a plurality of client signals in an optical signal in a format called as an optical channel transport unit (OTU) frame to carry out high capacity transmission. A client signal to be stored in an OTU frame may include a synchronous digital hierarchy (SDH) frame, a synchronous optical network (SONET) frame, and an Ethernet® frame. Therefore, the OTN technique is used as a high capacity transmission mechanism in a core network.

An OTU frame has one or more optical channel data units (ODUs) to flexibly store client signals at various transmission rates by mapping. An ODU has a plurality of transmission rates. For example, ITU-T Recommendation G.709 defines "ODU0" for 1.25 Gbps, "ODU1" for 5 Gbps, "ODU2" for 10 Gbps, "ODU3" for 40 Gbps, "ODU4" for 100 Gbps, and the like.

For example, a client signal at a transmission rate up to 100 Gbps (such as 100GBASE-R) is transmitted in the time division multiplexing system.

In order to carry out high capacity transmission, such as 400 Gbps and 1 Tbps, a highly multileveled modulation system, such as dual polarization (DP)—64 quadrature amplitude modulation (QAM), may be applied. When a multilevel modulation mechanism is applied to optical communication, the signal noise (SN) ratio decreases, so that the transmission range may be reduced.

In order to improve the SN ratio for long distance transmission, a multilevel modulation signal is taken as a subcarrier signal and a plurality of subcarrier signals are bundled by a wavelength multiplexing technique for transmission. A multicarrier signal obtained by bundling a plurality of subcarrier signals may be referred to as a "super-channel" and the like. A highly multileveled modulation system may also include, not only DP-64QAM, DP-QPSK (quaternary phase-shift keying) and DP-BPSK (binary phase-shift keying).

In a case of the OTN, a technique of ODU4Cn (bit rate: 100×n (Gbps) (n: natural number)) divides, for example, a client signal of more than 100 Gbps into a plurality of ODU4s having different wavelengths for storage to transmit in a super channel. For example, a client signal at a transmission rate of 400 Gbps (for example, 400GE) is stored in an OTN frame for transmission.

In such multicarrier transmission, the wavelength is different for each subcarrier signal and the spectrum at each wavelength is located in a narrow band to increase the transmission capacity. Therefore, in the multicarrier transmission, instead of a fixed bandwidth (for example, 50 GHz, 100 GHz, and the like), a flexible grid function that allows a variable bandwidth (such as 75 GHz and 137.5 GHz) is used. The flexible grid function is also called as a gridless function and defined in ITU-T Recommendation G.694.1.

In the transmission technique of ODU4Cn, one client signal (one frame signal) is processed for each ODU4 (plurality of subframes). Therefore, a transmission device processes the plurality of ODU4s in parallel using a plurality of lanes and carries out alarm detection and the like for each ODU4. For example, in a case of ODU4Cn at 100 Gbps, signal processing at 100 Gbps is carried out in each of the four lanes.

Regarding alarm detection processing, connection configuration where, for example, signals of different lines do not go through a circuit element in common is employed to search a table indicating connection relationship of a circuit element with a slot and a port, thereby specifying a defect area. In addition, for example, based on a table indicating a group path that a plurality of virtual paths belong to, channel switching when a defect occurs is carried out.

For example, since a plurality of ODU4s store one client signal as a whole, it may not be preferred to handle an alarm individually for each ODU4 for the operation, administration and maintenance (OAM) functions. When an alarm occurs in at least one of the plurality of ODU4s, the alarm may be detected as an alarm of the client signal, for example, an alarm of one communication line. Not limited to ODU4Cn, similar handling may be performed in other multicarrier transmission systems.

FIG. **1** illustrates one example of functional configuration of a transmission device. The transmission device is installed in, for example, a backbone network to transmit a plurality of optical signals (subcarrier signals) having different wavelengths based on a multicarrier transmission system.

The plurality of optical signals are multiplexed by the flexible grid function to be transmitted as a wavelength multiplexed optical signal (hereinafter, referred to as a "multiplexed optical signal"). The transmission device is not limited to the multicarrier transmission system and a plurality of optical signals may also be transmitted respectively via a plurality of transmission channels without wavelength multiplexing.

The transmission device has a plurality of interface units **1**, a switch unit **2**, a control unit **3**, a demultiplexer portion **4**, and a multiplexer portion **5**. The respective units **1** through **3**, the demultiplexer portion **4**, and the multiplexer portion **5** may be, for example, an electronic circuit board having electronic components, optical components, and the like mounted thereon and are stored respectively in a plurality of slots equipped in a housing of the transmission device. The respective units **1** through **3**, the demultiplexer portion **4**, and the multiplexer portion **5** are electrically coupled with each other via a wiring board equipped on a backside of the housing of the transmission device.

The demultiplexer portion **4** is coupled with one or more optical fibers (transmission channels) **6** and demultiplexes a multiplexed optical signal S**1** input from each optical fiber **6** for each wavelength to output a plurality of optical signals obtained by demultiplexing respectively to the plurality of interface units **1**. As the demultiplexer portion **4**, a wavelength selective switch may be used, for example. In this case, the demultiplexer portion **4** leads an optical signal at each wavelength to the respective interface unit **1** in accordance with wavelength setting carried out by the control unit **3**.

The plurality of interface units **1** receive optical signals input from the demultiplexer portion **4** to output to the switch unit **2**. The switch unit **2** outputs the optical signals inputted from the interface units **1** to other interface units **1** in accordance with the destinations following the switch setting by the control unit **3**. The interface units **1** carry out transmitting process of the optical signals input from the switch unit **2** to output the optical signals to the multiplexer portion **5**.

The multiplexer portion **5** is coupled with one or more optical fibers (transmission channels) **7** and multiplexes the plurality of optical signals input respectively from the plurality of interface units **1** to output to the optical fibers **7** as a multiplexed optical signal S**2**. As the multiplexer portion **5**, an optical coupler or a wavelength selective switch may be used, for example. In a case of a wavelength selective switch, the multiplexer portion **5** multiplexes the optical signals at the respective wavelength in accordance with the wavelength setting carried out by the control unit **3** to lead to the respective interface units **1**.

The control unit **3** carries out monitoring control of the entire transmission device and carries out, for example, switch setting of the switch unit **2** and wavelength setting of the demultiplexer portion **4** and the multiplexer portion **5**. The control unit **3** may be provided with a processor, such as a central processing unit (CPU), for example, and driven by software.

FIG. **2** illustrates one example of functional configuration of an interface unit and a switch unit. FIG. **2** illustrates, as one example, an implementation state of the interface units **1** of identification numbers (identifiers) #**1** through #**8** ("interface unit #**1**" through "interface unit #**8**").

The identification numbers of the interface units **1** may be, for example, inherent numbers of the interface units **1** (for example, serial numbers) and may also be numbers of the slots to which the interface units **1** are implemented in the housing of the transmission device. In the following descriptions, the interface units **1** of the identification numbers #**1** through #**8** are expressed as "interface unit (#**1**)" through "interface unit (#**8**)" to be distinguished from each other.

To the interface units (#**1** through #**4**) **1**, optical signals (frame signals) S**11** through S**14** having different wavelengths are respectively input from the demultiplexer portion **4**. The optical signals S**11** through S**14** are obtained by demultiplexing of the multiplexed optical signal S**1** in common by the demultiplexer portion **4**.

The optical signals S**11** through S**14** are formed respectively by, for example, OTU frames of 100 Gbps (ODU4s) to divide the client signal in common for storage. For example, the OTU frames of the optical signals S**11** through S**14** store data obtained respectively by dividing the client signal in common into four. The client signal may include, for example, a SDH frame, a SONET frame, an Ethernet® frame, and the like.

Therefore, the optical signals S**11** through S**14** are managed as a group G having the stored client signal in common. Similar to this, the interface units (#**1** through #**4**) **1** processing the optical signals S**11** through S**14** are also managed as the group G. The management of the group G may be carried out by the control unit **3** based on the identification numbers #**1** through #**8** of the respective interface units **1**.

After being input from the interface units (#**1** through #**4**) **1** via the switch unit **2** to the interface units (#**5** through #**8**) **1** respectively, the optical signals S**11** through S**14** are transmitted to another transmission device as optical signals S**25** through S**28**. The optical signals S**25** through S**28** are multiplexed to the multiplexed optical signal S**2** in common in the multiplexer portion **5**.

The optical signals S**25** through S**28** are managed as the group G having the stored client signal in common together with the interface units (#**5** through #**8**) **1**. Optical signals S**15** through S**18** input to the interface units (#**5** through #**8**) **1** and optical signals S**21** through S**24** output from the interface units (#**1** through #**4**) **1** are also managed as the group G, similarly.

Each interface units **1** has a transmission processing rate of, for example, 100 Gbps and carries out modulation process and demodulation process based on DP-BPSK. Accordingly, the four interface units (#**1** through #**4**, #**5** through #**8**) **1** that belong to the identical group G, as a whole, transmit a client signal of 400 Gbps. For example, the transmission device performs transmission process by dividing a client signal of 400 Gbps into four logical lanes (physical lanes).

The interface unit **1** includes a receiving portion **10**, an overhead (OH) extracting portion **11**, an alarm detecting portion (detecting portion) **12**, an ODU generation portion **13**, and an output converting portion **14**. The interface unit **1** has a transmitting portion **15**, an overhead (OH) insertion portion **16**, an alarm forwarding portion (forwarding process portion) **17**, an OTU generation portion **18**, and an input converting portion **19**. Although FIG. **2** illustrates configuration of the interface units (#**1**, #**5**) **1**, the other interface units (#**2** through #**4**, #**6** through #**8**) **1** may also have substantially the same or similar configuration.

The receiving portion **10** carries out receiving process of optical signals S**11** through S**18**. The receiving portion **10** converts the optical signals S**11** through S**18** to an electrical signal (optical/electrical conversion) to carry out demodulation process, frame synchronization process, serial-parallel conversion process (SerDes function), and the like of the electrical signal. The demodulation process may be carried out in accordance with the modulation system of the optical signals S**11** through S**18**. For example, as the modulation system, DP-BPSK may be used. The electrical signal output from the receiving portion **10** is expressed as an "OTU frame" or a "frame signal" in the following descriptions.

The OH extracting portion **11** extracts certain control information and the like from an overhead of an OTU frame. FIG. **3** illustrates one example of an OTU frame. An OTU frame has three regions to contain overheads, payload, and forward error correction (FEC), respectively. As a format of the optical signals S**11** through S**18**, the OTU frame defined in ITU-T Recommendation G.709 may be employed and a frame in another format may also be employed. The "OH" in FIG. **3** indicates an overhead.

The overhead region includes a frame alignment signal (FAS) overhead, an OTU overhead, an ODU overhead, and an optical channel payload unit (OPU) overhead. Each overhead includes various types of control information. The payload region is equipped with one or more tributary slots (TSs), which is a logical channel, to store a client signal for each TS.

FIG. **4** illustrates one example of an overhead of an OTU. In FIG. **4**, a "Row" and a "Column" may correspond respectively to the "Row" and the "Column" in FIG. **3**. The contents of "*1" through "*4" in the frame are illustrated respectively in "*1" through "*4" outside the frame.

The FAS overhead includes FAS and a multi-frame alignment signal (MFAS) and is used for frame synchronization process in the receiving portion **10**. Therefore, the FAS overhead has unique pattern data indicating the beginning of the OTU frame.

The OTU overhead provides a monitoring function and includes section monitoring (SM), a general communication channel (GCC) **0**, and reserved for future international standardization (RES). The SM includes a trail trace identifier (TTI) and bit interleaved parity level 8 (BIP-8). The SM further includes backward error indication (BEI)/backward incoming alignment error (BIAE), backward defect indication (BDI), an incoming alignment error (IAE), and RES.

The ODU overhead includes RES, path monitoring (PM) & tandem connection monitoring (TCM), TCM activation/deactivation control channel (ACT), TCMs **1** through **6**, and a fault type & fault location reporting channel (FTFL). The ODU overhead further includes PM, experimental (EXP), GCCs**1**, **2**, and automatic protection switching coordination channel (APS)/protection communication channel (PCC). The PM & TCM includes delay measurement of TCM (DMt) **1** through **6**, delay measurement of ODUk path (DMp), and RES.

The TCMs **1** through **6** respectively include a TTI, BIP-8, BEIi/BIAEi, BDIi, and status (STAT) i (i=1 through 6). The PM includes a TTI, BIP-8, BEI, BDI, and STAT.

The OPU overhead includes a payload structure identifier (PSI), justification control (JC), negative justification opportunity (NJO), positive justification opportunity (PJO), and RES. The RES is used as the JC in a case of a generic mapping procedure (GMP) operation. As each of the above parameters, the parameters defined in ITU-T Recommendation G.709 may also be used.

With reference to FIG. **2**, the alarm detecting portion **12** detects an alarm of a frame signal having a divided client signal stored therein. For example, the alarm detecting portion **12** detects an alarm of a frame signal based on the control information extracted by the OH extracting portion **11**. For example, the alarm detecting portion **12** detects an alarm (synchronization defect) when the receiving portion **10** fails to establish synchronization based on the FAS overhead.

As the control information used for the alarm detection processing, in a case of aAIS, taking ODUkT_TT_Sk as one example, the TCMs **1** through **6** and the PM in the overhead in FIG. **4** may be used, and in a case of aBDI, taking ODUkT_TT_Sk as one example, the SM, the TCMs **1** through **6**, the PM, the FAS, and the MFAS in the overheads may be used. For example, the STATi (a dAIS (alarm indication signal), dOCI (open connection indication), dLTC (loss of tandem connection), dLCT (locked defect), and the like) and the TTI (dTIM (trail trace identifier mismatch)) in the TCMs **1** through **6** are used. For the PM, the FAS, and the MFAS, an alarm of a lower layer (for the FAS and the MFAS, dLOS (loss of signal), dLOF (loss of frame), dLOM (loss of multiframe), and the like) is used.

The alarm detecting portion **12** is equipped for each interface unit **1**. The alarms of the respective frame signals obtained from the optical signals S**11** through S**18** are detected individually by the plurality of alarm detecting portions **12**. The alarm detecting portion **12** outputs the detected alarm to the output converting portion **14**. The alarm detecting portion **12** outputs the frame signal to the ODU generation portion **13**.

The ODU generation portion **13** converts the format of the frame signal from the OTU frames to an ODU frame. For example, the ODU generation portion **13** deletes the FAS overhead and the OTU overhead from the OTU frames. The ODU generation portion **13** outputs the ODU frame obtained by the conversion process to the output converting portion **14**.

The output converting portion **14** converts the ODU frame to a certain intra-device frame. FIG. **5** illustrates one example of an intra-device frame. The intra-device frame includes an overhead and a payload. The payload includes a payload of the ODU frame.

The overhead includes, for example, control information and alarm detection information in the ODU overhead. The alarm detection information is generated based on the alarm input from the alarm detecting portion **12** to be inserted into the overhead. The alarm detection information may include an alarm to be a factor of the AIS sent to another transmission device equipped on a downstream side of the transmission device and an alarm to be a factor of BDI sent to another transmission device equipped on an upstream side of the transmission device.

The alarm detection information may include, for example, ODUCn-aAIS, SM-aBDI, PM-aBDI, and TCM**1**-aBDI through TCM**6**-aBDI. It is indicated that the alarm is detected when the ODUCn-aAIS, the SM-aBDI, the PM-aBDI, and the TCM**1**-aBDI through TCM**6**-aBDI are "1", and it is indicated that the alarm is not detected when "0".

The ODUCn-aAIS is detected based on the TCMs **1** through **6** (STATi and TTI) and the PM (alarm of lower layer) in the overhead in FIG. **4** taking ODUkT_TT_Sk as one example. The SM-aBDI and PM-aBDI are detected respectively based on the SM (TTI) and the PM (alarm of lower layer, STATi, and TTI) in the overhead illustrated in FIG. **4** taking ODUkT_TT_Sk as one example. The TCM**1**-aBDI through TCM**6**-aBDI are detected respectively based on the TCMs **1** through **6** (STATi and TTI) in the overhead illustrated in FIG. **4** taking ODUkT_TT_Sk as one example. The generation of the aAIS and the aBDI may be carried out based on, for example, the generation system described in ITU-T Recommendation G.798.

With reference to FIG. **2**, the output converting portion **14** outputs the intra-device frame obtained by the conversion process to the switch unit **2**.

The switch unit **2** has a switch portion (SW) **20**, a plurality of input converting portions **21**, a plurality of alarm output portions **22**, a plurality of output converting portions **23**, a plurality of alarm generation portions (generation portions) **24**, and an alarm control portion (specifying portion) **25**. The input converting portions **21**, the alarm output portions **22**, the output converting portions **23**, and the alarm generation portions **24** are equipped corresponding to each interface unit **1**. The input converting portions **21**, the alarm output portions **22**, the output converting portions **23**, and the alarm generation portions **24** may be equipped in a number the same as the interface units **1** available for implementation to the transmission device.

The intra-device frame output from the output converting portion **14** of the interface unit **1** is input to the input converting portion **21**. The input converting portion **21** extracts alarm detection information from the overhead of the intra-device frame to output to the alarm output portion **22**. The input converting portion **21** converts the intra-device frame to an ODU frame to output to the alarm output portion **22**.

The alarm output portion **22** outputs the alarm detection information to the alarm control portion **25**. The alarm output portion **22** outputs the ODU frame to the switch portion **20**.

The switch portion **20** carries out switching control in such a manner that the ODU frame input from the alarm output portion **22** is outputted to the interface unit **1** in accordance with the destination following the switch setting from the control unit **3**. For example, the switch portion **20** outputs the ODU frame to the alarm generation portion **24** corresponding to the interface unit **1**. When destination information is given to the ODU frame, the switch portion **20** performs an output to the alarm generation portion **24** in accordance with the destination information instead of the above system.

The alarm control portion **25** specifies another frame signal to store the client signal in common with the frame signal in which an alarm is detected by the alarm detecting portion **12** among a plurality of frame signals based on group information **31***a* held by the control unit **3**. For example, the alarm control portion **25** specifies the interface unit **1** to forward an alarm of each frame signal that belongs to the identical group G from the identification numbers of the interface units **1** of the frame signals (optical signals S**11** through S**14**, S**15** through S**18**) in which an alarm is detected. The alarm control portion **25** designates generation of an alarm to the alarm generation portion **24** corresponding to the specified interface unit **1**.

The alarm generation portion **24** generates the alarm designated by the alarm control portion **25**. For example, the alarm generation portion **24** generates alarm detection information (refer to FIG. **5**) to be inserted into the overhead of the intra-device frame. At this time, the alarm in the alarm detection information (detected alarm) indicates "1" and another alarm (undetected alarm) indicates "0". The alarm generation portion **24** outputs the generated alarm detection information to the output converting portion **23**. The alarm generation portion **24** outputs the ODU frame input from the switch portion **20** to the output converting portion **23**. When there is no designation from the alarm control portion **25**, the alarm generation portion **24** outputs alarm detection information in which all alarms are "0" (undetected) to the output converting portion **23**.

The output converting portion **23** converts the ODU frame to an intra-device frame. The output converting portion **23** inserts the alarm detection information input from the alarm generation portion **24** into the overhead of the intra-device frame. The output converting portion **23** outputs the intra-device frame obtained by the conversion process to the input converting portion **19** of the interface unit **1**.

The input converting portion **19** extracts the alarm detection information from the overhead of the intra-device frame to output to the OH insertion portion **16**. The input converting portion **19** converts the intra-device frame to an ODU frame to output to the OTU generation portion **18**.

The OTU generation portion **18** converts the ODU frame to an OTU frame. For example, the OTU generation portion **18** gives an FAS overhead to the ODU frame (refer to FIG. **3**). The OTU generation portion **18** outputs the OTU frame obtained by the conversion process to the alarm forwarding portion **17**.

The alarm forwarding portion **17** forwards the alarm detected by the alarm detecting portion **12** and the alarm generated by the alarm generation portion **24** to another transmission device. In the entire network, detection information of an alarm of the transmission device is shared.

For example, when an alarm to be a factor of AIS is detected (when ODUCn-aAIS="1" in FIG. **5**), the alarm forwarding portion **17** outputs an instruction of generating AIS to the OH insertion portion **16**. The AIS is transmitted in a forward direction (downstream direction), for example, to another transmission to which the optical signals S**11** through S**18** are transmitted. For example, when an alarm to be a factor of AIS is detected in any of the optical signals S**11** through S**14**, the alarm is forwarded by that the AIS is transmitted from the interface units (#**5** through #**8**) **1** to the transmission device of the connection destination.

When an alarm to be a factor of BDI is detected (for example, SM-aBDI="1" in FIG. **5**), the alarm forwarding portion **17** outputs an instruction of generating BDI to the OH insertion portion **16**. The BDI is transmitted in a backward direction (upstream direction), for example, to another transmission device to be the source of transmitting of the optical signals S**11** through S**18**. For example, when an alarm to be a factor of BDI is detected in any of the optical signals S**11** through S**14**, the alarm is forwarded by that the BDI is transmitted from the interface units (#**1** through #**4**) **1** to the transmission device of the connection destination.

The OH insertion portion **16** inserts certain control information into the overhead of the OTU frame. When the instruction of generating AIS is input from the alarm forwarding portion **17**, the OH insertion portion **16** generates AIS to output to the transmitting portion **15**. The AIS (ODUk-AIS) may be a signal having the entire ODU overhead region other than the FTFL and the entire payload region which are made "1" (binary number) among the OTU frames.

When the instruction of generating BDI is input from the alarm forwarding portion **17**, the OH insertion portion **16** inserts the BDI into the overhead of the OTU frame to output to the transmitting portion **15**. For example, the OH insertion portion **16** makes the "BDI" or "BDIi" illustrated in FIG. **4** "1" (binary number) in accordance with the type of alarm to be a factor of BDI. For example, the OH insertion portion **16** makes the "BDI" in the "SM" "1" in a case of SM-aBDI. The type of alarm may be included in the instruction of generating BDI.

The transmitting portion **15** carries out transmitting process of the OTU frame. For example, the transmitting portion **15** carries out parallel-serial conversion process (SerDes function) and modulation process of the OTU frame to convert the OTU frame from an electrical signal to the optical signals S**21** through S**28** (electrical/optical conversion process). The modulation system of the transmitting portion **15** may be DP-BPSK.

The control unit **3** has a setting processing portion **30** and a memory portion **31**. The setting processing portion **30** may be, for example, a CPU and the memory portion **31** may be, for example, a memory mechanism, such as a non-volatile memory and a hard disk drive.

The setting processing portion **30** and the memory portion **31** are coupled with the switch unit **2** via an intra-device bus. The setting processing portion **30** carries out switch setting of the switch portion **20** in accordance with, for example, designation from a network management device.

The memory portion **31** stores the group information **31***a*. The group information **31***a* may be, for example, one of provisioning settings (initial setting information of the transmission device before operation) of the interface unit **1** and is set from the setting processing portion **30** in accordance with a user operation.

The group information **31***a* indicates the group G having a client signal stored therein in common regarding the plurality of frame signals (optical signals S**11** through S**14**, S**15** through S**18**). The group information **31***a* includes two tables in accordance with a forwarding direction of the alarm, for example, a forward direction and a backward direction. In the following descriptions, the table in the forward direction is expressed as a "forward table" and the table in the backward direction is expressed as a "backward table".

FIG. **6**A illustrates one example of a forward table. FIG. **6**B illustrates one example of a backward table.

The forward table indicates correspondence relationship between the identification numbers of the interface units **1** in which an alarm is detected and the identification numbers of the interface units **1** to forward the alarm in the forward direction by the AIS (forward interface units). For example, in the row of the identification number of the interface unit **1** in which an alarm is detected, the forward interface unit **1** in the column indicating "1" transmits AIS and the forward interface unit **1** in the column indicating "0" does not transmit AIS. For example, when the interface unit (#**1**) **1** detects an alarm, the interface units (#**5** through #**8**) **1** transmit AIS (refer to reference characters P**1**).

The backward table indicates correspondence relationship between the identification numbers of the interface units **1** in which an alarm is detected and the identification numbers of the interface units **1** to forward the alarm in the backward direction by BDI (backward interface units). For example, in the row of the identification number of the interface unit **1** in which an alarm is detected, the backward interface unit **1** in the column indicating "1" transmits BDI and the backward interface unit **1** in the column indicating "0" does not transmit BDI. For example, when the interface unit (#**1**) **1** detects an alarm, the interface units (#**1** through #**4**) **1** transmit BDI (refer to reference characters P**2**).

In such a manner, the group information **31***a* indicates the group G of the interface units **1**, for example, the group G of the frame signals (optical signals S**11** through S**18**, S**21** through S**28**). For example, the group information **31***a* indicates the alarm forwarding portion **17** to forward an alarm of each frame signal that belongs to the group G of the frame signal in which the alarm is detected among the plurality of frame signals. The alarm control portion **25** instructs generation of an alarm to the one or more alarm generation portions **24** in accordance with the alarm forwarding portion **17** indicated by the group information **31***a*.

The forwarding process of an alarm per group G may be carried out easily without being provided with complex hardware configuration, such as being equipped with wiring for control signals between all interface units **1**. Since the interface unit **1** to carry out the forwarding process of the alarm is searched easily from the group information **31***a*, the time taken for the forwarding process may be reduced. For example, there is a case that AIS is requested to be forwarded within 2 frames after detection of the alarm to be the factor.

The alarm control portion **25** may refer to the group information **31***a* stored in the memory portion **31** in the control unit **3**. For example, the switch unit **2** may also hold the group information **31***a* obtained from the memory portion **31** in a memory portion (such as a memory) in the switch unit **2** for reference.

FIG. **7** illustrates one example of a first behavior of a transmission device. In FIG. **7**, identical reference characters are given to substantially the same or similar configuration to FIG. **2** and the descriptions may be omitted or reduced.

The alarm detecting portion **12** of the interface unit (#**1**) **1** detects an alarm to be a factor of AIS (refer to "AIS detection"). At this time, in the other interface units (#**2** through #**4**) **1** in the identical group G, no alarm is detected (refer to "no alarm"). The detected alarm is notified to the alarm output portion **22** corresponding to the interface unit (#**1**) **1** by the alarm detection information (refer to broken lines). The alarm output portion **22** outputs the alarm detection information indicating occurrence of an alarm to the alarm control portion **25** (refer to "AIS output").

The alarm control portion **25** specifies the alarm generation portion **24** to be instructed to generate an alarm from the identification number #**1** of the interface unit **1** in which the alarm is detected by referring to the group information **31***a* (refer to "AIS generation designation destination specification"). Since the alarm generation portions **24** corresponding to the interface units (#**5** through #**8**) **1** become targets (refer to reference characters P**1** in FIG. **6**A), the alarm control portion **25** instructs each of the alarm generation portions **24** to generate the alarm.

The alarm generation portions **24** corresponding to the interface units (#**5** through #**8**) **1** generate an alarm (refer to "AIS generation"). For example, the alarm generation portions **24** generate alarm detection information that notifies of detection of an alarm. The generated alarm detection information is output to the alarm forwarding portion **17** of the interface units (#**5** through #**8**) **1** (refer to broken lines). The alarm forwarding portion **17** carries out forwarding process of the alarm, for example, generation process of AIS (refer to

"AIS forwarding"). The AIS is transmitted to another transmission device in the forward direction.

FIG. **8** illustrates one example of an alarm control portion and an alarm generation portion. FIG. **8** illustrates configuration of the alarm control portion **25** and the alarm generation portions **24** related to the first behavior example. A case is illustrated when an alarm ODUCn-aAIS to be a factor of AIS is detected in the alarm detecting portion **12** of the interface unit (#**1**) **1**.

The alarm control portion **25** has AND gates **251** through **258** corresponding to the respective interface units (#**1** through #**8**) **1**. To one of input terminals of the AND gates **251** through **258**, the ODUCn-aAIS (="1") in the alarm detection information is input. Although the AND gates **251** through **258** are equipped similarly for the other alarms in the alarm detection information, descriptions may be given only to the configuration for ODUCn-aAIS.

To the other input terminal of the AND gates **251** through **258**, values in the column of the forward interface units (#**1** through #**8**) **1** corresponding to the interface unit (#**1**) **1** in the forward table (refer to FIG. **6**A) are input respectively. For example, "0" is input to the other input terminal of the AND gates **251** through **254**, and "1" is input to the other input terminal of the AND gates **255** through **258**.

Therefore, as a result of logical operation, the AND gates **251** through **254** output "0" and the AND gates **255** through **258** output "1". The AND gates **251** through **258** output the logical operation values respectively to the alarm generation portions **24** of the interface units (#**1** through #**8**) **1**. FIG. **8** illustrates the alarm generation portions **24** of the interface units (#**5** through #**8**) **1** having the logical operation values corresponding to "1".

The alarm generation portion **24** has an OR gate **240** having input terminals (refer to "aAIS (#**1**)" through "aAIS (#**8**)") corresponding to the respective interface units (#**1** through #**8**) **1**. As a logical operation value "1" is input to at least one of the input terminals "aAIS (#**1**)" through "aAIS (#**8**)", the OR gate **240** outputs the alarm detection information to the interface unit **1**.

Since the alarm is detected in the interface unit (#**1**) **1**, the logical operation values of the AND gates **251** through **258** are input to the input terminal "aAIS (#**1**)" of the OR gate **240** of the alarm generation portion **24**. The logical operation values related to the AIS of the other interface units (#**2** through #**8**) **1** are input to the input terminals "aAIS (#**2**)" through "aAIS (#**8**)" of the OR gate **240**.

Since the AND gates **255** through **258** output "1", the OR gates **240** of the alarm generation portions **24** corresponding to the interface units (#**5** through #**8**) **1** output the alarm detection information respectively to the interface units (#**5** through #**8**) **1**. Thus, an alarm of each frame signal that belongs to the group G of the frame signal in which the alarm is detected is generated to be forwarded by the AIS.

Since the AND gates **251** through **254** output "1", the OR gates **240** of the alarm generation portions **24** corresponding to the interface units (#**1** through #**4**) **1** do not output alarm detection information to the interface units (#**1** through #**4**) **1**. Therefore, the interface units (#**1** through #**4**) **1** do not transmit AIS. Although the AND gates **251** through **254** for AIS are illustrated, the alarm generation portions **24** are equipped similarly with AND gates for BDI.

When generation process and forwarding process of an alarm is carried out by hardware, such as the AND gates **251** through **258** and the OR gates **240**, the time may be reduced in comparison with processing by software.

FIG. **7** and FIG. **8** illustrate behaviors when an alarm to be a factor of AIS is detected. When an alarm to be a factor of BDI is detected, substantially similar behaviors in which only tables of the group information **31***a* referred by the alarm control portion **25** are different may also be carried out.

FIG. **9** illustrates one example of a second behavior of a transmission device. In FIG. **9**, identical reference characters are given to substantially the same or similar configuration to FIG. **2** and the descriptions may be omitted or reduced.

The alarm detecting portion **12** of the interface unit (#**1**) **1** detects an alarm to be a factor of BDI (refer to "BDI detection"). At this time, no alarm is detected in the other interface units (#**2** through #**4**) **1** of the identical group G (refer to "no alarm"). The detected alarm is notified to the alarm output portion **22** corresponding to the interface units (#**1**) **1** by the alarm detection information (refer to broken lines). Then, the alarm output portion **22** outputs the alarm detection information indicating occurrence of an alarm to the alarm control portion **25** (refer to "BDI output").

The alarm control portion **25** specifies the alarm generation portion **24** to be instructed to generate an alarm from the identification number #**1** of the interface unit **1** in which the alarm is detected by referring to the group information **31***a* (refer to "BDI generation designation destination specification"). Since the alarm generation portions **24** corresponding to the interface units (#**1** through #**4**) **1** become targets (refer to reference characters P**2** in FIG. **6**B), the alarm control portion **25** instructs each of the alarm generation portions **24** to generate the alarm.

The alarm generation portions **24** corresponding to the interface units (#**1** through #**4**) **1** generate the alarm (refer to "BDI generation"). For example, the alarm generation portions **24** generate alarm detection information that notifies of detection of the alarm. The generated alarm detection information is output to the alarm forwarding portion **17** of the interface units (#**1** through #**4**) **1** (refer to broken lines). The alarm forwarding portion **17** carries out forwarding process of an alarm, for example, generation process of BDI (refer to "BDI forwarding"). The BDI is transmitted to another transmission device in the backward direction.

FIG. **10** illustrates one example of functional configuration of an interface unit and a switch unit. In FIG. **10**, identical reference characters are given to substantially the same or similar configuration to FIG. **2** and the descriptions may be omitted or reduced.

The transmission device illustrated in FIG. **2** carries out multicarrier transmission at 400 Gbps using the eight interface units (#**1** through #**8**) **1** having transmission capacity of 100 Gbps. The transmission device illustrated in FIG. **10** uses four interface units (#**1** through #**4**) **1** having transmission capacity of 100 Gbps and two interface units (#**5**, #**6**) **1** having transmission capacity of 200 Gbps. Therefore, multicarrier transmission at 400 Gbps is carried out.

The interface units (#**1** through #**4**) **1** modulate frame signals by DP-BPSK whereas the interface units (#**5**, #**6**) **1** modulate frame signals by DP-QPSK. According to DP-BPSK, 2-bit data is coded by modulation process in one time. According to DP-QPSK, 4-bit data is coded by modulation process in one time.

Therefore, the transmission capacity of the interface units (#**5**, #**6**) **1** is twice the interface units (#**1** through #**4**) **1**. The transmitting portions **15** of the interface units (#**5**, #**6**) **1** output OTU frames respectively as two optical signals S**25***a*, S**25***b*, S**26***a*, S**26***b*. To the receiving portions **10** of the interface units (#**5**, #**6**) **1**, respectively two optical signals S**15***a*, S**15***b*, S**16***a*, S**16***b* are input. The functions of the other portions **11** through **14** of the interface units (#**5**, #**6**) **1** may be similar to the functions described above.

Since the configuration of the interface units **1** is different from the configuration illustrated in FIG. **2** or FIG. **9**, the group information **31***a* may also be different. FIG. **11**A illustrates one example of a forward table. FIG. **11**B illustrates one example of a backward table.

A method of referring to each table illustrated in FIG. **11**A and FIG. **11**B is similar to each table illustrated in FIG. **6**A and FIG. **6**B. For example, when the interface unit (#**1**) **1** detects an alarm to be a factor of AIS, the interface units (#**5**, #**6**) **1** transmit AIS (refer to reference characters P**3** in FIG. **11**A). For example, when the interface unit (#**1**) **1** detects an alarm to be a factor of BDI, the interface units (#**1** through #**4**) **1** transmit BDI (refer to reference characters P**4** in FIG. **11**B).

FIG. **12** illustrates one example of a third behavior of a transmission device. In FIG. **12**, identical reference characters are given to substantially the same or similar configuration to FIG. **10** and the descriptions may be omitted or reduced.

The alarm detecting portion **12** of the interface unit (#**1**) **1** detects an alarm to be a factor of AIS (refer to "AIS detection"). At this time, no alarm is detected in the other interface units (#**2** through #**4**) **1** in the identical group G (refer to "no alarm"). The detected alarm is notified to the alarm output portion **22** corresponding to the interface unit (#**1**) **1** by the alarm detection information (refer to broken lines). Then, the alarm output portion **22** outputs alarm detection information indicating occurrence of the alarm to the alarm control portion **25** (refer to "AIS output").

The alarm control portion **25** specifies the alarm generation portion **24** to be instructed to generate an alarm from the identification number #**1** of the interface unit **1** in which the alarm is detected by referring to the group information **31***a* (refer to "AIS generation designation destination specification"). Since the alarm generation portions **24** corresponding to the interface units (#**5**, #**6**) **1** become targets (refer to reference characters P**3** in FIG. **11**A), the alarm control portion **25** instructs each of the alarm generation portions **24** to generate the alarm.

The alarm generation portions **24** corresponding to the interface units (#**5**, #**6**) **1** generates an alarm (refer to "AIS generation"). For example, the alarm generation portions **24** generate alarm detection information that notifies of detection of the alarm. The generated alarm detection information is output to the alarm forwarding portions **17** of the interface units (#**5**, #**6**) **1** (refer to broken lines). The alarm forwarding portions **17** carry out forwarding process of the alarm, for example, generation process of AIS (refer to "AIS forwarding"). The AIS is transmitted to another transmission device in the forward direction.

FIG. **13** illustrates one example of an alarm control portion and an alarm generation portion. FIG. **13** illustrates configuration of the alarm control portion **25** and the alarm generation portions **24** related to the third behavior. In the alarm detecting portion **12** of the interface unit (#**1**) **1**, an alarm ODUCn-aAIS to be a factor of AIS is detected. In FIG. **13**, identical reference characters are given to substantially the same or similar configuration to FIG. **8** and the descriptions may be omitted or reduced.

To one of input terminals of the AND gates **251** through **256**, ODUCn-aAIS (="1") in the alarm detection information is input. Based on the forward table (refer to FIG. **11**A), "0" is input to the other input terminals of the AND gates **251** through **254** and "1" is input to the other input terminals of the AND gates **255**, **256**.

As a result of a logical operation, the AND gates **251** through **254** output "0" to the alarm generation portions **24** corresponding to the interface units (#**1** through #**4**) **1**. The AND gates **255**, **256** output "1" to the alarm generation portions **24** corresponding to the interface units (#**5**, #**6**) **1**. Therefore, "1" is input to the input terminal "aAIS (#**1**)" of the OR gates **240** of the respective alarm generation portions **24** corresponding to the interface units (#**5**, #**6**) **1**.

The OR gates **240** of the alarm generation portions **24** corresponding to the interface units (#**5**, #**6**) **1** output the alarm detection information respectively to the interface units (#**5**, #**6**) **1**. An alarm of each frame signal that belongs to the group G of the frame signal in which the alarm is detected is generated to be forwarded by the AIS.

In the third behavior illustrated in FIG. **12** and FIG. **13**, an alarm to be a factor of AIS is detected. When an alarm to be a factor of BDI is detected, substantially similar behaviors in which only tables of the group information **31***a* referred by the alarm control portion **25** are different may also be carried out.

FIG. **14** illustrates one example of a fourth behavior of a transmission device. In FIG. **14**, identical reference characters are given to substantially the same or similar configuration to FIG. **10** and the descriptions may be omitted or reduced.

The alarm detecting portion **12** of the interface unit (#**1**) **1** detects an alarm to be a factor of BDI (refer to "BDI detection"). At this time, no alarm is detected in the other interface units (#**2** through #**4**) **1** of the identical group G (refer to "no alarm"). The detected alarm is notified to the alarm output portion **22** corresponding to the interface unit (#**1**) **1** by the alarm detection information (refer to broken lines). The alarm output portion **22** outputs alarm detection information indicating occurrence of the alarm to the alarm control portion **25** (refer to "BDI output").

The alarm control portion **25** specifies the alarm generation portion **24** to be instructed to generate an alarm from the identification number #**1** of the interface unit **1** in which the alarm is detected by referring to the group information **31***a* (refer to "BDI generation designation destination specification"). For example, since the alarm generation portions **24** corresponding to the interface units (#**1** through #**4**) **1** become targets (refer to reference characters P**4** in FIG. **11**B), the alarm control portion **25** instructs each of the alarm generation portions **24** to generate the alarm.

The alarm generation portions **24** corresponding to the interface units (#**1** through #**4**) **1** generate the alarm (refer to "BDI generation"). For example, the alarm generation portions **24** generate alarm detection information that notifies of detection of the alarm. The generated alarm detection information is output to the alarm forwarding portion **17** of the interface units (#**1** through #**4**) **1** (refer to broken lines). The alarm forwarding portion **17** carries out forwarding process of the alarm, for example, generation process of BDI (refer to "BDI forwarding"). The BDI is transmitted to another transmission device in the backward direction.

The transmission device has a plurality of detecting portions (alarm detecting portions) **12**, a memory portion **31**, a specifying portion (alarm control portion) **25**, and one or more generation portions (alarm generation portions) **24**. The plurality of detecting portions **12** respectively detect alarms of a plurality of frame signals (OTU frames) in which divided client signals are stored, respectively.

The memory portion **31** stores group information **31***a* indicating the group G having a client signal in common stored therein regarding the plurality of frame signals. The specifying portion **25** specifies another frame signal to store a client signal in common with the frame signal in which the alarm is detected among the plurality of frame signals based on the group information **31***a*. The one or more generation portions **24** generate an alarm of the other frame signal specified by the specifying portion **25**.

When the detecting portion **12** detects an alarm of the frame signal, the specifying portion **25** specifies the other frame signal that belongs to the group G having the client signal stored therein in common with the frame signal. The generation portion **24** generates an alarm of the other frame signal specified by the specifying portion **25**.

When an alarm is detected in one of the frame signals to store a client signal in common, the transmission device issues an alarm to another frame signal, so that the alarm detection function may be improved.

All examples and conditional language recited herein are intended for pedagogical purposes to aid the reader in understanding the invention and the concepts contributed by the inventor to furthering the art, and are to be construed as being without limitation to such specifically recited examples and conditions, nor does the organization of such examples in the specification relate to a showing of the superiority and inferiority of the invention. Although the embodiments of the present invention have been described in detail, it should be understood that the various changes, substitutions, and alterations could be made hereto without departing from the spirit and scope of the invention.

What is claimed is:

1. A transmission device comprising:

a plurality of detectors configured to respectively detect alarms of a plurality of frame signals having divided client signals respectively;

a memory configured to store group information indicating a group in which the client signal is in common regarding the plurality of frame signals;

a specifying portion configured to specify, based on the group information, a second frame signal storing the client signal in common with a first frame signal in which a first alarm is detected by one of the plurality of detectors among the plurality of frame signals; and

one or more generators configured to generate a second alarm for the second frame signal.

2. The transmission device according to claim **1**, further comprising:

a plurality of forwarding process portions configured to forward the first alarm or the second alarm to another device.

3. The transmission device according to claim **1**, wherein

the group information includes a forwarding process portion to forward the second alarm or a third alarm for a third frame signal that belongs to the group of the first frame signal among the plurality of frame signals.

4. The transmission device according to claim **2**, wherein

the forwarding process portion is provided corresponding to each of the plurality of detectors.

5. The transmission device according to claim **4**, wherein

the group information includes correspondence relationship between identification information of the plurality of detectors and identification information of the forwarding process portion.

6. The transmission device according to claim **3**, wherein

the specifying portion instructs the one or more generators to generate the second alarm in accordance with the forwarding process portion indicated by the group information, and

the one or more generators generate the second alarm in accordance with an instruction.

7. A method of controlling a transmission device, comprising:

detecting, by a plurality of detectors, respectively alarms of a plurality of frame signals having divided client signals respectively;

specifying a second frame signal to store the client signal in common with a first frame signal in which a first alarm is detected among the plurality of frame signals based on group information in a memory indicating a group in which the client signal is in common regarding the plurality of frame signals; and

generating a second alarm for the second frame signal.

8. The method according to claim **7**, further comprising:

forwarding the first alarm or the second alarm to another device.

9. The method according to claim **7**, wherein

the group information includes a forwarding process portion to forward the second alarm or a third alarm for a third frame signal that belongs to the group of the first frame signal among the plurality of frame signals.

10. The method according to claim **7**, wherein

the forwarding process portion is provided corresponding to each of the plurality of detectors.

11. The method according to claim **10**, wherein

the group information includes correspondence relationship between identification information of the plurality of detectors and identification information of the forwarding process portion.

12. The method according to claim **9**, further comprising:

issuing an instruction to generate the second alarm in accordance with the forwarding process portion indicated by the group information; and

generating the second alarm in accordance with the instruction.

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